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Editorial: Reducing CO₂ emissions and maintaining economic capability

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Managing climate change without national or global economies shrinking can only occur with significant change—and risk taking. Reduced economic activity, recession, increases in unemployment and poverty, and declines in health standards come with their own very real risks. As well as the social and personal cost, however, there are security issues. We also face rapidly changing patterns in the global supply and demand of energy, and these present significant security risks in their own right. As the International Energy Agency (IEA)¹ states, however, energy insecurity does not just mean physical unavailability, but also includes prices that are uncompetitive or overly volatile. During 2008 oil markets have certainly become significantly more volatile, with an associated impact on other energy prices. It is engineers who can quantify and prioritise these risks, create solutions and propose mitigations, which enable informed choices.

This issue of *Energy* considers how we can quantify these risks and looks at the changes needed to energy production and consumption. Papers included look at forecasting energy supply and demand, the efficient use of energy in transport and housing, and alternative greenhouse gas mitigations. These changes can be thought of in three groups: political, technical and commercial. Politically, leadership, direction and consistency are essential to allow research and development to be focused effectively and market mechanisms to work efficiently. Technically, electricity generation must emit significantly lower levels of CO₂ and its use be made more efficient. Commercially, large-scale and long-term investments in new energy-related infrastructure are necessary.

1. POLITICAL CHANGES AND CHALLENGES

In terms of global energy, China's energy demand is already huge and is growing rapidly. While China's energy resources—especially coal—are extensive, they will not meet all the growth in its energy needs. China's primary energy demand is projected to more than double from 2005 to 2030, and the country will become the world's largest energy consumer soon after 2010. To match this demand, China needs to add more than 1300 GW to its electricity generating capacity.² Zhi-Sheng *et al.*'s paper 'Neural network prediction of energy demand and supply in China' therefore addresses an issue of fundamental global importance: anticipating China's future need for energy.

Forecasting future energy needs is central to establishing effective investment frameworks in centrally planned and market economies. Zhi-Sheng *et al.*'s paper looks at how neural networks can predict electricity supply and demand in one of the world's fastest growing economies. The paper gives a clear indication of the difficulties that even supposedly 'planned' economies face. Even actual production and consumption statistics vary between internal agencies, and difference in actual annual energy demand of 11.1% (2003–2007) compared to 3.8% predicted by the Chinese National Bureau of Statistics for the same period are clearly of international significance.

Forecasting supply and demand is never easy, and over the time frames necessary for the large scales typically necessary when investing in energy infrastructure it is particularly uncertain. The analysis by the Victorian economist Jevons,³ in 1861, forecast that 100 000 million t of coal would be required by 1970, exceeding the then known stocks of coal of 83 000 million t. The underlying assumption, however, did not account for the future expansion of oil, and global crises and conflicts. While coal production did decline rapidly from the 1970s,⁴ the UK was still producing deep-mined coal in excess of 100 million t/year through to the 1980s, and the pattern of coal use varied significantly from Jevons' forecast.

Perfect markets only exist in textbook examples, and all markets, energy included, have some formal or informal regulation to manage participants' behaviour. Establishing and maintaining effective energy market regulation and policy objectives is, given the volatile global energy market, at best difficult. So Kemp's briefing 'Do politicians understand what they have promised?', addressing whether government objectives to reduce man-made CO₂ emissions globally by 5% by 2012, and in UK transport by 80% over the next 40 years, are feasible, is important in assessing the achievability of such objectives.

The paper identifies the developments needed in the national transport infrastructure to achieve this long-term challenge. These include: expanding urban mass transit systems, enabling an electrical distribution capacity to support widespread use of electric and hybrid vehicles, a massive expansion of inter-urban rail capacity and the associated expansion of low carbon (renewable and nuclear) electricity generation power.

2. TECHNICAL CHALLENGES: REDUCING ENERGY INTENSITY

One of the key lessons from history is that technical developments can radically alter forecasts. In the areas of housing and transport there is much hope that reducing carbon intensity, and overall emissions, will deliver a large part of these energy savings.

Ko and Fenner's paper 'Adoption of energy efficiency innovations in new UK housing' addresses what should be the easy part, new build. Given the UK government's objectives to develop ten new 'Ecotowns' as part of meeting housing targets, the lesson this paper highlights needs to be heard if the domestic carbon footprint is to be reduced. The paper highlights a complex policy framework in the UK housing market where there are significant performance gaps in terms of energy efficiency levels achieved compared to international comparators. This is in part due to the complex set of relationships that exist in the housing sector between a range of private and public parties, which engrains certain barriers to innovation and the adoption of best practice.

The authors go into length detailing possible responses to these problems, and given the willingness of all parties, believe it is possible to accelerate the introduction of energy efficiency innovations into new UK housing. While this does not address the harder part of reducing domestic carbon, from the existing housing stock, it can lead to a knock-on effect of introducing these same innovations when redeveloping and refurbishing existing properties.

Gibbins *et al.*'s paper on 'Electric vehicles for low-carbon transport' continues the energy in transport theme from the previous issue. The paper makes a detailed review of current alternative technologies and concludes that, in the short term, hybrid electric vehicles, supported by favourable tax and local charging regimes, will help support the wider application of low carbon transport technologies. The author acknowledges that one of the major obstacles will be simultaneously developing the vehicles and building the infrastructure to supply the charge to the vehicles. This is, however, an area where government involvement in the market, by starting to build this infrastructure first, could significantly accelerate the programme.

3. COMMERCIAL CHALLENGES: LARGE-SCALE AND LONG-TERM INVESTMENTS

The need for energy sources that combine a low environmental impact and low prices continues to grow worldwide. Coal, which powered the industrial revolution, remains one of the most abundant and widely available primary sources of energy globally. However, its use for electricity generation has carried a high environmental cost. Not only the significant emissions from its combustion, but also the environmental impact associated with its extraction; either deep mined or open cast. By converting coal into gas for use in integrated gasification combined cycle (IGCC) generators, emissions of CO₂ have been minimised. However, these schemes have high capital costs and limited operational flexibility, and are still limited to the traditional methods of extraction.

Walker's paper on 'Commercial development of underground coal gasification' considers an alternative way for accessing the energy

in coal in situ. The paper describes the history of UGC, the process and the technical aspects, and how these meet the environmental concerns in a commercial and safe way. The key technical issue is how to determine remotely the characteristics of the coal seam. The characteristics affect gas composition, consistency and its availability, and is a complex geological and geotechnical problem, requiring that the permeability, fault structure and hydrogeology of the surrounding strata be fully understood. As many engineers know, working below ground carries significant risks and these factors determine the economic viability of accessing deep seams necessary for UGC to succeed.

Accessing below ground resources is also a major part of making carbon capture and storage (CCS) work. CCS needs to move from pilot schemes and into full commercial operation if it is to make a serious contribution to emissions reduction. However, feasibility on a commercial scale has been not been proved. In his briefing 'CCS—an ambitious contribution to combat climate change' Linkohr argues that CCS will need to be implemented on a large scale. Fossil fuels will be an integral part of the future energy mix, and the CO₂ emissions produced will need to be captured, transported and stored. This will require an open access pipeline infrastructure to link coal and gas fired plants to depleted oil and gas fields. However, given the typical distance from these fields that much industry is, Linkohr suggests that to achieve widespread adoption there will need to be a link to saline aquifers closer to industry. In addition to the significant technical challenges of making CCS work commercial, this presents engineers with the additional challenge of achieving the acceptance and consent of the local population to their use and development.

4. CONCLUSION

The risks faced are often hidden in the detail of day-to-day life, and as end users measurement of the gas and electricity we use is at best crude, represented by a quarterly bill. High prices will drive behaviour change, though, and technological developments mean we will be able to manage our own energy use better. As yet society has not fully come to terms with what is needed. While the change needed is cultural as much as technological, engineers still have to explain the risks and mitigations of the different alternatives open to us.

There is a lot for engineers to get stuck into: electrical infrastructure to support widespread adoption of electrical vehicles, solving the geotechnical problems associated with UGC, capturing and storing CO₂ economically and safely. The challenges of depleting resources and the environmental impact of man's existence on the planet continue. Decisions about energy infrastructure are difficult, but they cannot be ignored. Resolving when, where and how energy is sourced, managed and distributed affects us all.

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